(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 May 2018 (24.05.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/094199 A1

(51) International Patent Classification:
C08L 23/04 (2006.01) *B32B 27/32* (2006.01)

(21) International Application Number:
PCT/US2017/062282

(22) International Filing Date:
17 November 2017 (17.11.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/424,117 18 November 2016 (18.11.2016) US

(71) Applicant: **DOW GLOBAL TECHNOLOGIES LLC** [US/US]; 2040 Dow Center, Midland, MI 48674 (US).

(72) Inventors: **PEREZ, Carmelo Declet**; 230 Abner Jackson Parkway, Herbert H. Dow Building / 4B165, Lake Jackson, TX 77566 (US). **WALTHER, Brian W.**; 2301 N. Brazosport Blvd., Building B-1607, Freeport, TX 77541 (US). **COOPER, James L.**; 1069 Riverview Ranch, Brazoria, TX 77422 (US). **BROWN, Hayley A.**; 230 Abner Jackson Parkway, Herbert H. Dow Building/4B154, Lake Jackson, TX 77566 (US).

(74) Agent: **LINK, J. Jason**; The Dow Chemical Company, P.O. Box 1967, Midland, Michigan 48641-1967 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WO 2018/094199 A1

(54) Title: POLYMER BLENDS FOR USE IN MULTILAYER STRUCTURE AND MULTILAYER STRUCTURES COMPRISING THE SAME

(57) Abstract: The present invention provides polymer blends that can be used in a multilayer structure and to multilayer structures comprising one or more layers formed from such blends. In one aspect, a polymer blend comprises a copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate having an acrylate content of 5 to 40 weight percent based on the weight of the copolymer and having a melt index (I_2) of 1 to 60 g/10 minutes, wherein the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises 45 to 99 weight percent of the blend based on the total weight of the blend, and a polyolefin having a density of 0.870 g/cm^3 or more and having a melt index (I_2) of 20 g/10 minutes or less, wherein the polyolefin comprises 1 to 55 weight percent of the blend based on the total weight of the blend.

POLYMER BLENDS FOR USE IN MULTILAYER STRUCTURE AND MULTILAYER STRUCTURES COMPRISING THE SAME

Field

The present invention relates to polymer blends that can be used in a multilayer structure and to multilayer structures comprising one or more layers formed from such polymer blends.

Introduction

Certain resins are used in tie layers in multilayer structures to provide adhesion between film layers and metal substrates such as aluminum. Despite a variety of resins being available for use in such tie layers, in some instances, some common tie layer resins can contribute negatively to the temperature sensitivity of the tie layer. Thus, there remains a need for alternative approaches for tie layers that can provide desirable adhesion to foil, metallized film, or similar substrates in multilayer structures while also providing other improvements over conventional approaches to tie layers.

Summary

The present invention provides polymer blends that in some aspects provide desirable adhesion when used as a tie layer in a multilayer structure. Further, in some aspects, the present invention facilitates extrusion coating to form multilayer structures while minimizing undesirable effects such as draw down and neck-in. For example, embodiments of the present invention comprise a carefully selected blend of resins to achieve desirable adhesion.

In one aspect, the present invention provides a polymer blend that comprises a copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate having an acrylate content of 5 to 40 weight percent based on the weight of the copolymer and having a melt index (I_2) of 1 to 60 g/10 minutes, wherein the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises 45 to 99 weight percent of the blend based on the total weight of the blend, and a polyolefin having a density of 0.870 g/cm^3 or more and having a melt index (I_2) of 20 g/10 minutes or less, wherein the polyolefin comprises 1 to 55 weight percent of the blend based on the total weight of the blend.

In another aspect, the present invention provides a multilayer structure comprising at least two layers, each layer having opposing facial surfaces, wherein Layer A comprises any of the polymer blends of the present invention disclosed herein, and wherein Layer B comprises a substrate, wherein a top facial surface of Layer B is in adhering contact with a bottom facial surface of Layer A. In some embodiments, the substrate comprises aluminum foil.

These and other embodiments are described in more detail in the Detailed Description.

Detailed Description

Unless stated to the contrary, implicit from the context, or customary in the art, all parts and percents are based on weight, all temperatures are in °C, and all test methods are current as of the filing date of this disclosure.

The term "composition," as used herein, refers to a mixture of materials which comprises the composition, as well as reaction products and decomposition products formed from the materials of the composition.

"Polymer" means a polymeric compound prepared by polymerizing monomers, whether of the same or a different type. The generic term polymer thus embraces the term homopolymer (employed to refer to polymers prepared from only one type of monomer, with the understanding that trace amounts of impurities can be incorporated into the polymer structure), and the term interpolymer as defined hereinafter. Trace amounts of impurities (for example, catalyst residues) may be incorporated into and/or within the polymer. A polymer may be a single polymer, a polymer blend or polymer mixture.

The term "interpolymer," as used herein, refers to polymers prepared by the polymerization of at least two different types of monomers. The generic term interpolymer thus includes copolymers (employed to refer to polymers prepared from two different types of monomers), and polymers prepared from more than two different types of monomers.

The terms "olefin-based polymer" or "polyolefin", as used herein, refer to a polymer that comprises, in polymerized form, a majority amount of olefin monomer, for example ethylene or propylene (based on the weight of the polymer), and optionally may comprise one or more comonomers.

"Polypropylene" means a polymer having greater than 50 wt% units derived from propylene monomer.

The term, "ethylene/α-olefin interpolymer," as used herein, refers to an interpolymer that comprises, in polymerized form, a majority amount of ethylene monomer (based on the weight of the interpolymer), and a α-olefin.

The term, "ethylene/α-olefin copolymer," as used herein, refers to a copolymer that comprises, in polymerized form, a majority amount of ethylene monomer (based on the weight of the copolymer), and a α-olefin, as the only two monomer types.

The term "in adhering contact" and like terms mean that one facial surface of one layer and one facial surface of another layer are in touching and binding contact to one another such that one layer cannot be removed from the other layer without damage to the interlayer surfaces (i.e., the in-contact facial surfaces) of both layers.

The terms "comprising," "including," "having," and their derivatives, are not intended to exclude the presence of any additional component, step or procedure, whether or not the same is specifically disclosed. In order to avoid any doubt, all compositions claimed through use of the term "comprising" may include any additional additive, adjuvant, or compound, whether polymeric or otherwise, unless stated to the contrary. In contrast, the term, "consisting essentially of" excludes from the scope of any succeeding recitation any other component, step or procedure, excepting those that are not essential to operability. The term "consisting of" excludes any component, step or procedure not specifically delineated or listed.

"Polyethylene" or "ethylene-based polymer" shall mean polymers comprising greater than 50% by weight of units which have been derived from ethylene monomer. This includes polyethylene homopolymers or copolymers (meaning units derived from two or more comonomers). Common forms of polyethylene known in the art include Low Density Polyethylene (LDPE); Linear Low Density Polyethylene (LLDPE); Ultra Low Density Polyethylene (ULDPE); Very Low Density Polyethylene (VLDPE); single-site catalyzed Linear Low Density Polyethylene, including both linear and substantially linear low density resins (m-LLDPE); Medium Density Polyethylene (MDPE); and High Density Polyethylene (HDPE). These polyethylene materials are generally known in the art; however, the

following descriptions may be helpful in understanding the differences between some of these different polyethylene resins.

The term "LDPE" may also be referred to as "high pressure ethylene polymer" or "highly branched polyethylene" and is defined to mean that the polymer is partly or entirely homopolymerized or copolymerized in autoclave or tubular reactors at pressures above 14,500 psi (100 MPa) with the use of free-radical initiators, such as peroxides (see for example US 4,599,392, which is hereby incorporated by reference). LDPE resins typically have a density in the range of 0.916 to 0.935 g/cm^3.

The term "LLDPE", includes both resin made using the traditional Ziegler-Natta catalyst systems as well as single-site catalysts, including, but not limited to, bis-metallocene catalysts (sometimes referred to as "m-LLDPE") and constrained geometry catalysts, and includes linear, substantially linear or heterogeneous polyethylene copolymers or homopolymers. LLDPEs contain less long chain branching than LDPEs and includes the substantially linear ethylene polymers which are further defined in U.S. Patent 5,272,236, U.S. Patent 5,278,272, U.S. Patent 5,582,923 and US Patent 5,733,155; the homogeneously branched linear ethylene polymer compositions such as those in U.S. Patent No. 3,645,992; the heterogeneously branched ethylene polymers such as those prepared according to the process disclosed in U.S. Patent No. 4,076,698; and/or blends thereof (such as those disclosed in US 3,914,342 or US 5,854,045). The LLDPEs can be made via gas-phase, solution-phase or slurry polymerization or any combination thereof, using any type of reactor or reactor configuration known in the art.

The term "MDPE" refers to polyethylenes having densities from 0.926 to 0.935 g/cm^3. "MDPE" is typically made using chromium or Ziegler-Natta catalysts or using single-site catalysts including, but not limited to, bis-metallocene catalysts and constrained geometry catalysts, and typically have a molecular weight distribution ("MWD") greater than 2.5.

The term "HDPE" refers to polyethylenes having densities greater than about 0.935 g/cm^3, which are generally prepared with Ziegler-Natta catalysts, chrome catalysts or single-site catalysts including, but not limited to, bis-metallocene catalysts and constrained geometry catalysts.

The term "ULDPE" refers to polyethylenes having densities of 0.880 to 0.912 g/cm^3, which are generally prepared with Ziegler-Natta catalysts, chrome catalysts, or single-site catalysts including, but not limited to, bis-metallocene catalysts and constrained geometry catalysts.

The term "multilayer structure" refers to any structure comprising two or more layers having different compositions and includes, without limitation, multilayer films, multilayer sheets, laminated films, multilayer rigid containers, multilayer pipes, and multilayer coated substrates.

Unless otherwise indicated herein, the following analytical methods are used in the describing aspects of the present invention:

"Density" is determined in accordance with ASTM D792.

"Melt index": Melt indices I_2 (or I2) and I_{10} (or I10) are measured in accordance with ASTM D-1238 at 190° C and at 2.16 kg and 10 kg load, respectively. Their values are reported in g/10 min. "Melt flow rate" is used for polypropylene based resins and determined according to ASTM D1238 (230° C at 2.16 kg).

"Acrylate content": The acrylate content of ethylene/methyl acrylate copolymers and ethylene/ethyl acrylate copolymers is measured in accordance with ASTM D4094.

"Adhesion to metal substrate": The adhesion of a layer to metal substrate is determined using a 180 degree peel test based on ASTM F904 with a crosshead speed (as specified) of 3 inches/minute or 10 inches/minute.

"Viscosity at 190 °C and 1000 s^{-1}": A Rheotester 2000 capillary rheometer with a stainless steel, flat entrance die of 1 mm diameter and 20 mm length (L/D ratio of 20) is used to generate the flow curve of a polymer. Tests are performed at 190 °C. Apparent shear rates are specified from 150 to 10000 s^{-1} and 5 logarithmically spaced points are collected per decade. The resin is packed into a 15 mm diameter barrel and allowed to melt for 10 min prior to the test. A rod can be used as a stopper at the bottom of the capillary during the soak time to avoid dripping of the material from the reservoir. The speed of the piston is controlled to achieve the specified apparent shear rates. The flowing molten polymer is allowed to reach equilibrium at each imposed shear rate before taking the corresponding measurement. As known to those of skill in the art, the apparent shear rate and the shear stress at the wall are calculated based on the dimensions of the capillary, the

pressure drop across the capillary, and the speed of the piston. The corrected shear viscosity of the resin is calculated by taking the ratio of the shear stress at the wall to the corrected shear rate. The corrected shear rate is obtained by applying the Weissenberg-Rabinowitsch correction. The Bagley correction was not applied to this calculation. The viscosity of the polymer at 190 °C and a corrected shear rate of 1000 s^{-1} is determined using a linear interpolation process. The logarithm of the corrected shear viscosity and the logarithm of the corrected shear rate are taken for the closest point below and the closest point above a corrected shear rate of 1000 s^{-1}. The slope and intercept of a line passing through these two points is calculated to obtain an equation expressing the logarithm of the corrected shear viscosity as a function of the logarithm of the corrected shear rate. This equation is used to determine the value of the logarithm of the corrected shear viscosity at a value of the logarithm of the corrected shear rate equal to 3 ($\log_{10}$ of 1000). The interpolated shear viscosity value at a corrected shear rate of 1000 s^{-1} is finally calculated by taking the antilog of the logarithm of the corrected shear viscosity.

Additional properties and test methods are described further herein.

In one aspect, the present invention provides a polymer blend that comprises a copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate having an acrylate content of 5 to 40 weight percent based on the weight of the copolymer and having a melt index (I_2) of 1 to 60 g/10 minutes, wherein the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises 45 to 99 weight percent of the blend based on the total weight of the blend, and a polyolefin having a density of 0.870 g/cm^3 or more and having a melt index (I_2) of 20 g/10 minutes or less, wherein the polyolefin comprises 1 to 55 weight percent of the blend based on the total weight of the blend. In some embodiments, the polyolefin comprises linear low density polyethylene, low density polyethylene, high density polyethylene, medium density polyethylene, polyolefin plastomer, polyolefin elastomer, polypropylene, ethylene/cyclic olefin copolymer, or a combination thereof. The polyolefin comprises low density polyethylene or linear low density polyethylene in some embodiments. In some embodiments, instead of, or in addition to polyolefin, the polymer blend further comprises polystyrene. In some embodiments, the relative viscosity ratio of the polyolefin to the

ethylene/(m)ethyl acrylate copolymer is <0.35. In some embodiments, the viscosity ratio of polyolefin to the ethylene/(m)ethyl acrylate copolymer is greater than 1 and less than 10.

In some embodiments, the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises greater than 50 weight percent of the blend, and the polyolefin comprises less than 50 weight percent of the blend. The total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises greater than 55 weight percent of the blend, and the polyolefin comprises less than 45 weight percent of the blend in some embodiments.

In some embodiments, the polymer blend further comprises an inorganic filler. The inorganic filler, in some embodiments, comprises calcium carbonate, magnesium carbonate, or a combination thereof. In some embodiments wherein the polymer blend comprises an inorganic filler, the inorganic filler comprises up to 50 weight percent of the blend based on the total weight of the blend.

In some embodiments, the polymer blend further comprises at least one of an oxidant, a colorant, a slip agent, an antiblock, a processing aid, or a combination thereof.

The polymer blend can comprise a combination of two or more embodiments as described herein.

Embodiments of the present invention also relate to multilayer structures that include a layer formed from a polymer blend of the present invention. In one aspect, a multilayer structure comprises at least two layers, each layer having opposing facial surfaces, wherein Layer A comprises a polymer blend according to any of the embodiments disclosed herein, wherein Layer B comprises a substrate, and wherein a top facial surface of Layer B is in adhering contact with a bottom facial surface of Layer A. In some embodiments, the substrate comprises aluminum foil or metallized film. The adhesion of Layer A to Layer B is at least 1.5 N/inch when measured using a 180 degree peel test based on ASTM F904 with a crosshead speed of 10 inches/minute, in some embodiments. The adhesion of Layer A to Layer B, in some embodiments, is at least 3 N/inch when measured using a 180 degree peel test based on ASTM F904 with a crosshead speed of 10 inches/minute. The adhesion of Layer A to Layer B is at least 4 N/inch when measured using a 180 degree peel test based on ASTM F904 with a crosshead speed of 10

inches/minute, in some embodiments. In some embodiments, Layer A is extrusion coated on Layer B at a melt temperature of 300 °C.

In some embodiments, the multilayer structure further comprises Layer C, wherein a top facial surface of Layer A is in adhering contact with a bottom facial surface of Layer C. In some such embodiments, Layer C comprises a polyolefin.

Multilayer structures of the present invention comprise a combination of two or more embodiments as described herein.

Embodiments of the present invention also relate to articles comprising any of the multilayer structures (e.g., multilayer films) disclosed herein.

Polymer Blends

Polymer blends according to embodiments of the present invention comprise a copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate having certain features specified herein and a polyolefin having certain features as specified herein. For ease of reference, the copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate will also be referred to herein as "ethylene/(m)ethyl acrylate copolymer" with the understanding that some such copolymers can comprise both methyl acrylate monomer and ethyl acrylate monomer.

The ethylene/(m)ethyl acrylate copolymer used in embodiments of the present invention is characterized as a random copolymer. Such ethylene/(m)ethyl acrylate copolymers can be prepared at high pressure by the action of a free-radical polymerization initiator, acting on a mixture of ethylene and methyl acrylate and/or ethyl acrylate monomers using techniques known to those of skill in the art. The ethylene/(m)ethyl acrylate copolymers used in polymer blends of the present invention are more precisely referred to as interpolymers because they are formed by the polymerization of a mixture of the comonomers, in contradistinction to copolymers made by "grafting" or "block-polymerization" methods.

The ethylene/(m)ethyl acrylate copolymer used in some embodiments of the present invention can be characterized as having an acrylate content of 5 to 40 weight percent based on the weight of the copolymer. The ethylene/(m)ethyl acrylate copolymer has an acrylate content of 10 to 40 weight percent based on the weight of the copolymer in some

embodiments. The ethylene/(m)ethyl acrylate copolymer has an acrylate content of 15 to 40 weight percent based on the weight of the copolymer in some embodiments.

The ethylene/(m)ethyl acrylate copolymer may further be characterized as having a melt index (I_2) of 1 to 60 g/10 minutes in some embodiments. All individual values and subranges between 1 and 60 g/10 minutes are included herein and disclosed herein. For example, the ethylene/(m)ethyl acrylate copolymer can have a melt index from a lower limit of 1, 5, 10, 15, or 20 g/10 minutes to an upper limit of 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 g/10 minutes. In some embodiments, the ethylene/(m)ethyl acrylate copolymer has a melt index (I_2) of 1 to 40 g/10 minutes, and 1 to 30 g/10 minutes in some embodiments.

The polymer blend comprises 45 to 99 weight percent ethylene/(m)ethyl acrylate copolymer based on the weight of the blend in some embodiments. In some embodiments, the polymer blend comprises greater than 50 weight percent ethylene/(m)ethyl acrylate copolymer based on the weight of the blend in some embodiments. In some embodiments, the polymer blend comprises at least 55 weight percent of the ethylene/(m)ethyl acrylate copolymer based on the weight of the blend. In some embodiments, the polymer blend can comprise greater than 50 to 95 wt% ethylene/(m)ethyl acrylate copolymer based on the weight of the blend. All individual values and subranges from 50 to 99 wt% are included and disclosed herein; for example, the amount of the ethylene/(m)ethyl acrylate copolymer in the polymer blend can be from a lower limit of 50, 55, 60, 65, 70, 75, or 80 wt% to an upper limit of 75, 80, 85, 90, 95, or 99 wt%. For example, the amount of ethylene/(m)ethyl acrylate copolymer in the polymer blend can be from 50 to 99 wt%, or in the alternative, from 55 to 95 wt%, or in the alternative, from 55 to 85 wt%, or in the alternative, from 57 to 75 wt%.

Examples of commercially available ethylene/(m)ethyl acrylate copolymers that can be used in embodiments of the present invention include AMPLIFY™ EA ethylene/ethyl acrylate copolymers, such as AMPLIFY™ EA 100, AMPLIFY™ EA 101, AMPLIFY™ EA 102, and AMPLIFY™ EA 103, which were commercially available from The Dow Chemical Company, ELVALOY ethylene/methyl acrylate copolymers commercially available from DuPont, OPTEMA TC ethylene/methyl acrylate copolymers commercially available from ExxonMobil, LOTRYL ethylene/methyl acrylate copolymers commercially

available from Akema, and ethylene/ethyl acrylate copolymers available from SK Global Chemical Co., LTD.

In addition to an ethylene/(m)ethyl acrylate copolymer, polymer blends of the present invention further comprise a polyolefin having a density of 0.870 g/cm^3 or more and a melt index (I_2) of 20 g/10 minutes or less. Such polyolefins can include polymers that comprises, in polymerized form, a majority amount of ethylene or propylene monomer (based on the weight of the polymer), and optionally may comprise one or more comonomers.

In some embodiments, the polyolefin comprises a polyethylene having a density of 0.870 g/cm^3 or more and a melt index (I_2) of 20 g/10 minutes or less. All individual values and subranges from equal to or greater than 0.870 g/ cm^3 are included and disclosed herein; for example the density of the polyethylene can be equal to or greater than 0.870 g/ cm^3, or in the alternative, equal to or greater than 0.900 g/ cm^3, or in the alternative, equal to or greater than 0.910 g/ cm^3, or in the alternative, equal to or greater than 0.925 g/ cm^3, or in the alternative, equal to or greater than 0.935 g/cm^3. In a particular embodiment, the polyethylene has a density equal or less than 0.970 g/cm^3. All individual values and subranges from equal to or less than 0.970 g/cm^3 are included and disclosed herein. For example, the density of the polyethylene can be equal to or less than 0.970 g/cm^3, or in the alternative, equal to or less than 0.960 g/cm^3, or in the alternative, equal to or less than 0.955 g/cm^3, or in the alternative, equal to or less than 0.950 g/cm^3, or in the alternative, equal to or less than 0.940 g/cm^3. When the polyolefin comprises polypropylene, persons of skill in the art can identify an appropriate density for the polypropylene based on the teachings herein.

In some embodiments, the polyolefin has a melt index (I_2) of 20 g/10 minutes or less. All individual values and subranges up to 20 g/10 minutes are included herein and disclosed herein. For example, the polyolefin can have a melt index from a lower limit of 0.2, 0.25, 0.5, 0.75, 1, 2, 4, 5, 10 or 15 g/10 minutes to an upper limit of 1, 2, 4, 5, 10, or 15 g/10 minutes. The polyolefin has a melt index (I_2) of up to 15 g/10 minutes in some embodiments. The polyolefin has a melt index (I_2) of up to 10 g/10 minutes in some embodiments. In some embodiments, the polyolefin has a melt index (I_2) less than 5 g/10 minutes.

Polyethylenes that are particularly well-suited for use in some embodiments of the present invention include linear low density polyethylene (LLDPE), low density polyethylene (LDPE), high density polyethylene (HDPE), medium density polyethylene (MDPE), polyolefin elastomers, polyolefin plastomers, cyclic olefin copolymers, olefin block copolymers, and combinations thereof. In some embodiments, the polyolefin comprises low density polyethylene (LDPE) and/or linear low density polyethylene (LLDPE).

When the polyolefin comprises LDPE and/or LLDPE, the density of the LDPE or LLDPE will typically be in the range of 0.916 to 0.935 g/cm^3. When the polyolefin comprises HDPE, the density of the HDPE will typically be in the range of greater than 0.935 g/cm^3 up to 0.970 g/cm^3.

Examples of commercially available LDPE that can be used in embodiments of the present invention include DOW™ LDPE 132i, DOW™ LDPE 722, and AGILITY™ 1021, as well as other low density polyethylenes, which are commercially available from The Dow Chemical Company. Examples of commercially available LLDPE that can be used in embodiments of the present invention include DOWLEX™ linear low density polyethylene, such as DOWLEX™ 2045 as well as others, which are commercially available from The Dow Chemical Company. Examples of commercially available HDPE that can be used in embodiments of the present invention include DOW™ HDPE resins, which are commercially available from The Dow Chemical Company. In addition to HDPE resins, the polyolefin used in the polymer blend can also include enhanced polyethylenes having densities greater than 0.935 g/cm^3. Examples of commercially available enhanced polyethylene resins having high densities that can be used in embodiments of the present invention include ELITE™ enhanced polyethylene resins which are commercially available from The Dow Chemical Company. Further, in some embodiments, the polyolefin used in the polymer blend can also include enhanced polyethylenes having densities of 0.935 g/cm^3 or less such as, for example, ELITE™ enhanced polyethylenes commercially available from The Dow Chemical Company. Examples of commercially available polyolefin plastomers that can be used in embodiments of the present invention include AFFINITY™ polyolefin plastomers, which are commercially available from The Dow Chemical Company. Examples of commercially available olefin block copolymers that can be used in

embodiments of the present invention include INFUSE™ olefin block copolymers, which are commercially available from The Dow Chemical Company.

Persons of skill in the art can select suitable commercially available polypropylenes for use in polymer blends based on the teachings herein.

The polymer blend comprises 1 to 55 weight percent polyolefin based on the weight of the blend in some embodiments. In some embodiments, the polymer blend comprises 50 weight percent or less polyolefin based on the weight of the blend in some embodiments. In some embodiments, the polymer blend comprises less than 45 weight percent of the polyolefin based on the weight of the blend. In some embodiments, the polymer blend can comprise 5 to 50 wt% polyolefin based on the weight of the blend. All individual values and subranges from 1 to 55 wt% are included and disclosed herein; for example, the amount of polyolefin in the polymer blend can be from a lower limit of 1, 5, 10, 15, 20, 25, 30, 35, or 40 wt% to an upper limit of 25, 30, 35, 40, 45, 50, or 55 wt%. For example, the amount of polyolefin in the polymer blend can be from 1 to 50 wt%, or in the alternative, from 5 to 45 wt%, or in the alternative, from 15 to 45 wt%, or in the alternative, from 25 to 43 wt%.

The relative viscosity ratio of the polyolefin to the ethylene/(m)ethyl acrylate copolymer can be important in some embodiments. As used herein, "relative viscosity ratio" or "RVR" refers to the melt index (I_2) of a first component divided by the melt index (I_2) of a second component. Thus, the RVR of the polyolefin to the ethylene/(m)ethyl acrylate copolymer is determined by dividing the melt index (I_2) of the polyolefin by the melt index (I_2) of the ethylene/(m)ethyl acrylate copolymer. In some embodiments, the RVR of the polyolefin to the ethylene/(m)ethyl acrylate copolymer is less than 0.35, preferably less than 0.20. While not wishing to be bound by any particular theory, it is believed that such RVR values for polyolefin to ethylene/(m)ethyl acrylate copolymer contribute to desirable adhesion when used as a tie layer in a multilayer structure and particularly when one of the layers is a metal foil or metallized film. Further, in some embodiments, the adhesion strength to a layer of aluminum foil can be adjusted by changing the RVR of the polyolefin to the ethylene/(m)ethyl acrylate copolymer.

The viscosity ratio of the polyolefin to the ethylene/(m)ethyl acrylate copolymer can be important in some embodiments. As used herein, "viscosity ratio" refers to the viscosity of a first component divided by the viscosity of a second component when the viscosity is

determined at a temperature of 190 °C at an applied shear rate of 1000 s^{-1}. Thus, the viscosity ratio of the polyolefin to the ethylene/(m)ethyl acrylate copolymer is determined by dividing the determined viscosity of the polyolefin by the determined viscosity of the ethylene/(m)ethyl acrylate copolymer. To calculate the "viscosity ratio" between two components as used herein, the viscosity at 190 °C and 1000 s^{-1} of each component is measured as described above.

In some embodiments, the viscosity ratio of the polyolefin to the ethylene/(m)ethyl acrylate copolymer, when viscosities are measured as described above at 190 °C under an applied shear rate of 1,000 s^{-1}, is greater than 1 and less than 10, preferably greater than 1.3 and less than 10, and more preferably greater than 1.5 and less than 5. While not wishing to be bound by any particular theory, it is believed that such viscosity ratio values for polyolefin to ethylene/(m)ethyl acrylate copolymer contribute to desirable adhesion when used as a tie layer in multilayer structure and particularly when one of the layers is a metal foil or a metallized film. Persons skilled in the art should recognize that the determined viscosity of each component in a polymer blend used to calculate the viscosity ratio between the components is bound to change based on processing conditions. Experimentally accessible conditions are used as a reference to measure the viscosities of the components, and are not intended to serve as limits for any of the embodiments disclosed herein. In some embodiments, the polymer blend further comprises one or more inorganic fillers. Examples of inorganic fillers that can be incorporated in polymer blends according to some embodiments include calcium carbonate, magnesium carbonate, or a combination thereof. Inorganic fillers can be included in some embodiments to reduce costs, improve sealing properties, improve prints, or other reasons. The polymer blend comprises up to 50 weight percent inorganic filler based on the weight of the blend in some embodiments. All individual values and subranges from 0 to 50 wt% are included and disclosed herein; for example, the amount of inorganic filler in the polymer blend can be from a lower limit of 1, 5, 10, 15, 20, 25, 30, 35, or 40 wt% to an upper limit of 25, 30, 35, 40, 45, or 50 wt%.

In some embodiments, the polymer blend can further comprise one or more additives known to those of skill in the art including, for example, antioxidants, colorants, slip agents, antiblocks, processing aids, and combinations thereof. In some embodiments,

the polymer blend comprises up to 5 weight percent of such additives. All individual values and subranges from 0 to 5 wt% are included and disclosed herein; for example, the total amount of additives in the polymer blend can be from a lower limit of 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, or 4.5 wt% to an upper limit of 1, 2, 3, 4, or 5 wt%.

As will be discussed below, a polymer blend of the present invention can be incorporated/converted into a final fabricated product (e.g., a multilayer structure) via extrusion coating (or other equipment) using techniques known to those of skill in the art based on the teachings herein.

Polymer blends of the present invention can be prepared by melt blending the prescribed amounts of the components with a twin screw extruder before feeding into an extrusion coater (or other equipment) for film fabrication. Such polymer blends can also be prepared by tumble blending the prescribed amounts of the components before feeding into the extrusion coater (or other equipment) for film fabrication. In some embodiments, polymer blends of the present invention can be in the form of pellets. For example, the individual components can be melt blended and then formed into pellets using a twin screw extruder or other techniques known to those of skill in the art based on the teachings herein. In some embodiments, a polymer blend can include the combination of a compounded pellet and additional polymer that is tumble blended before feeding into the extrusion coater. For example, a pellet comprising a blend of ethylene/(m)ethyl acrylate copolymer and polyolefin (e.g., LDPE) can be tumble blended with additional polyolefin (e.g., additional LDPE) to provide a polymer blend having the desired weight percentages of ethylene/(m)ethyl acrylate copolymer and polyolefin.

Multilayer Structures

In some embodiments, the present invention relates to multilayer structures in which at least one layer is formed from a polymer blend according to any embodiment disclosed herein. The multilayer structure, in some embodiments, comprises at least two layers, with each having opposing facial surfaces. In such embodiments, a first layer (Layer A) (e.g., a layer comprising a polymer blend of the present invention) is in adhering contact with a second layer (Layer B), with a top facial surface of the second layer (Layer B) being in adhering contact with a bottom facial surface of the first layer (Layer A).

In embodiments wherein a first layer (Layer A) is formed from a polymer blend of the present invention, a second layer (Layer B) can comprise a substrate. Examples of substrates that can be used as the second layer (Layer B) in embodiments of the present invention include metal foils, woven mats (e.g., woven fiber glass mats), nonwoven mats (e.g., nonwoven fiber glass mats), scrims, metallized films (e.g., metallized PET), and polymeric films (e.g., oriented polypropylene, oriented PET, etc.). Polymer blends of the present invention are particularly useful in adhering to metal foils or metallized films. Any metal foil or metallized film may form the substrate onto which the polymer blend layer is applied. Exemplary metal foils include aluminum foil and copper foil. The foil, when present, may, but need not, be flame or corona treated or subjected to other treatment so as to improve wettability and/or adhesion. Exemplary metallized films include metallized PET films, metallized oriented polypropylene films, metallized polyamide films, and metallized polyethylene films. In some embodiments, substrates other than metal foils can also be flame or corona treated or subjected to other treatment so as to improve wettability and/or adhesions. In some such embodiments, the substrates comprise oriented polypropylene or oriented polyamide films. Persons of skill in the art can identify such substrates based on the teachings herein.

In some embodiments, a multilayer structure of the present invention comprises a first layer (Layer A) formed from a polymer blend according to any of the embodiments disclosed herein and a second layer (Layer B) comprising a metal substrate (e.g., a metal foil or a metallized film) in adhering contact with the first layer, wherein the adhesion of the first layer to metal substrate (e.g., metal foil) is at least 1.5 N/inch when measured using a 180 degree peel test based on ASTM F904 with a crosshead speed of 10 inches/minute, at least 3 N/inch in some embodiments, and at least 4 N/inch in other embodiments. In some embodiments, the metal substrate is aluminum foil.

In embodiments wherein the multilayer structure includes a metal foil layer (e.g., an aluminum foil layer), the metal foil has a thickness from 0.20 to 2.0 mil, more preferably from 0.20 to 0.50 mil. All individual values and subranges from 0.20 to 0.50 mil are included and disclosed herein; for example, the metal foil layer thickness can range from a lower limit of 0.20, 0.25, 0.30, 0.35, 0.40 or 0.45 mil to an upper limit of 0.30, 0.35, 0.40, 0.45, or 0.50 mil. For example, the metal foil layer thickness can range from 0.20 to 0.50

mil, or in the alternative, from 0.20 to 0.60 mil, or in the alternative, from 0.60 to 1.0 mil, or in the alternative, from 0.25 to 0.50 mil. To one skilled in the art the thickness of the metal foil layer is defined as sufficient for the application.

In embodiments wherein the multilayer structure includes a metallized film layer (e.g., a metallized PET film, a metallized oriented polypropylene film, a metallized polyamide film, or a metallized polyethylene film), the metallized layer on the film can have a variety of thicknesses depending on factors such as performance (e.g., barrier properties, opacity, etc.) and cost. In some embodiments, the metallized layer on the metallized film layer has a thickness from 3 to 40 nm. All individual values and subranges from 3 to 40 nm are included and disclosed herein; for example, the metallized layer thickness can range from a lower limit of 3, 5, 10, 17, 20, 22, 25, 30, or 35 nm to an upper limit of 10, 12, 15, 20, 23, 25, 32, 35, 37, or 40 nm. To one skilled in the art the thickness of the metallized layer of the metallized film is defined as sufficient for the application.

The layer formed from the polymer blend can be applied to a metal substrate layer (e.g., metal foil) by any acceptable manner, such as extrusion lamination and/or extrusion coating. In extrusion coating the polymer blend layer on the metal substrate layer (e.g., metal foil), in some embodiments, the polymer blends can maintain acceptable levels of neck-in and draw down speed while providing acceptable adhesion to the metal foil layer. Polymer blends of the present invention, in some embodiments, can be extrusion coated on a metal substrate layer at temperatures (e.g., ~300 °C or less) lower than temperatures (e.g., ~320 °C) used when a polymer layer comprising only low density polyethylene is extrusion coated, while still providing acceptable adhesion to the metal substrate. Thus, the ability to extrusion coat at a relatively lower temperature while achieving acceptable adhesion is one advantage of some embodiments of the present invention.

In some embodiments, a layer formed from a polymer blend of the present invention can be in adhering contact with another layer, in addition to a substrate (e.g., in addition to a metal foil layer). For example, in some embodiments, the layer formed from the polymer blend can additionally be in adhering contact with a layer comprising a polyolefin. That is, in such embodiments, the layer formed from a polymer blend of the present invention can be between the polyolefin layer and the substrate (e.g., the metal foil), with a top facial surface of the substrate being in adhering contact with a bottom facial

surface of the polymer blend layer, and with a top facial surface of the polymer blend layer being in adhering contact with a bottom facial surface of the polyolefin layer.

In embodiments comprising a polyolefin layer, the polyolefin can be any polyethylene, polypropylene, and their derivatives (e.g., ethylene-propylene copolymer) known to those of skill in the art to be suitable for use as a layer in a multilayer structure based on the teachings herein. For example, the polyethylene that can be used in such a layer, as well as other layers in the multilayer structure, in some embodiments, can be ultralow density polyethylene (ULDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), medium density polyethylene (MDPE), high density polyethylene (HDPE), high melt strength high density polyethylene (HMS-HDPE), ultrahigh density polyethylene (UHDPE), homogeneously branched ethylene/α-olefin copolymers made with a single site catalyst such as a metallocene catalyst or a constrained geometry catalyst, and combinations thereof. In some embodiments, polyethylenes used in the polyolefin layer can be made via gas-phase polymerization. In some embodiments, polyethylenes used in the polyolefin layer can be made by gas-phase, solution-phase or slurry polymerization or any combination thereof, using any type of reactor or reactor configuration known in the art.

Some embodiments of multilayer structures can include layers beyond those described above. For example, while not necessarily in adhering contact with a layer formed from a polymer blend according to the present invention (though, in some embodiments, such layers can be in contact with the layer formed from such a polymer blend), a multilayer structure can further comprise other layers typically included in multilayer structures depending on the application including, for example, barrier layers, sealant layers, tie layers, other polyethylene layers, polypropylene layers, etc. Additionally, other layers such as printed, high modulus, high gloss layers may be laminated to multilayer structures (e.g., films) of the present invention. Further, in some embodiments, the multi-layer structure can be extrusion coated to a fiber containing substrate such as paper or fiber glass (e.g., nonwoven mats, woven mats, scrims, and the like).

In addition to extrusion coating, multilayer structures of the present invention can be coextruded as blown films or cast films using techniques known to those of skill in the art based on the teachings herein. In some embodiments, multilayer structures of the present

invention can also be formed by lamination or by a combination of blown/cast film followed by thermal lamination.

Packaging

In some embodiments, the present invention relates to packaging comprising the multilayer structure of any embodiment disclosed herein. In a particular embodiment, the packaging is a retort and/or sterilization packaging. The packaging may be used to contain, in various embodiments, solids, slurries, liquids, or gasses. By way of example and not limitation, the packaging may be used to contain acidic solutions, corn oil, alcohols, meats, cheeses, sun screen, shampoo, spice, soy sauce, creamer, flavored coffee, milk, juice, detergent, aseptic food, hot fill juice, fatty food, baby wipe, iodine solution, salad dressing, ketchup, sauces, and other items.

Some embodiments of the invention will now be described in detail in the following Examples.

Examples

The following raw materials are used in the examples discussed below:

Product	Melt Index (I_2) (dg/min)	Density (g/cc)	Acrylate type	Acrylate Content (wt %)
DOW™ LDPE 722	8.0	0.9180	--	--
AGILITY™ 1021	1.85	0.9195	--	--
DOW™ LDPE 132i	0.25	0.9210	--	--
DOWLEX™ 2045	1.0	0.9200	--	--
ELVALOY™ AC 1609	6.0	0.9300	Methyl acrylate	9.0
ELVALOY™ AC 1820	8.0	0.9420	Methyl acrylate	20.0
ELVALOY™ AC 2618	6.0	0.9300	Ethyl acrylate	18.0

DOW™ LDPE 722, AGILITY™ 1021, DOW™ LDPE 132i are each low density polyethylene resins commercially available from The Dow Chemical Company. DOWLEX™ 2045 is a linear low density polyethylene commercially available from The Dow Chemical Company. ELVALOY™ AC 1609, ELVALOY™ AC 1820, and ELVALOY™ AC 2618 are each ethylene/acrylate copolymers commercially available from DuPont.

The viscosity at 190 °C and 1000 s^{-1} for each of the raw materials is determined

using the procedure described above. The relevant data and viscosities are as follows:

Product	1st Viscosity Measurement [Shear rate]	2nd Viscosity Measurement [Shear rate]	Viscosity at 190 °C and 1000 s^{-1}
DOW™ LDPE 722	131.96 Pa-s [784.78 s^{-1}]	101.23 Pa-s [1292.03 s^{-1}]	116.01 Pa-s
AGILITY™ 1021	159.79 Pa-s [891.24 s^{-1}]	116.93 Pa-s [1436.94 s^{-1}]	148.20 Pa-s
DOW™ LDPE 132i	254.34 Pa-s [950.89 s^{-1}]	179.85 Pa-s [1551.73 s^{-1}]	245.44 Pa-s
DOWLEX™ 2045	560.79 Pa-s [578.29 s^{-1}]	354.99 Pa-s [1047.62 s^{-1}]	367.93 Pa-s
ELVALOY™ AC 1609	149.73 Pa-s [805.12 s^{-1}]	113.75 Pa-s [1322.25 s^{-1}]	132.79 Pa-s
ELVALOY™ AC 1820	126.54 Pa-s [787.81 s^{-1}]	97.26 Pa-s [1288.22 s^{-1}]	111.38 Pa-s
ELVALOY™ AC 2618	144.98 Pa-s [803.92 s^{-1}]	110.02 Pa-s [1326.15 s^{-1}]	128.55 Pa-s

The examples set forth below are used to illustrate the adhesion of inventive polymer blends to an aluminum substrate. The aluminum substrate used in each of the examples is prepared as follows. A bleached, 30 pounds per ream paper is extrusion laminated to 0.00035 inch (0.35 mil) Grade A wettable aluminum foil using DOW™ LDPE 722 (The Dow Chemical Company). The laminated sheet is then cut into 3-4 foot lengths to provide the aluminum substrate. Masking tape is applied to the lead edge of the aluminum substrate. The aluminum substrate is not corona treated in the below examples.

Example 1

A variety of multilayer structures are prepared as shown in Table 1:

Table 1

	Layer A (percentages are weight %)	**Layer B (Substrate)**
Comparative Example A	100% LDPE 722	Aluminum substrate
Comparative Example B	100% ELVALOY™ AC 2618	Aluminum substrate
Comparative Example C	60% ELVALOY™ AC 2618 40% LDPE 722	Aluminum substrate
Inventive Example 1	60% ELVALOY™ AC 2618 40% AGILITY™ 1021	Aluminum substrate
Inventive Example 2	60% ELVALOY™ AC 2618 40% LDPE 132i	Aluminum substrate
Inventive Example 3	60% ELVALOY™ AC 2618 40% DOWLEX™ 2045	Aluminum substrate
Inventive Example 4	80% ELVALOY™ AC 2618 20% DOWLEX™ 2045	Aluminum substrate

Layer A is coated as a monolayer onto the aluminum substrate as described below.

All of the examples herein are prepared by extrusion coating the polymer layer (Layer A) onto the aluminum substrate (Layer B) utilizing a Black Clawson extrusion coater. Pellets of the polymer used for Layer A in Comparative Examples A and B are fed directly from a box of commercial material. Layer A in Comparative Example C and Inventive Examples 1 - 4 are prepared by tumble blending the prescribed amounts of the two components for approximately 30 minutes prior to feeding the blend to the extrusion coater. The aluminum substrate is dropped down onto the moving 50 pounds/ream Kraft paper just prior to the chill roll/rubber roll nip where the aluminum substrate is pulled into the nip thus applying Layer A onto the foil side of the aluminum substrate. The resulting flow rate from the die is ~10 pounds/hour of polymer per inch of die opening. A constant air gap of 6 inches is used in fabricating the sample. Each sample consists of a 1 mil thick monolayer of Layer A coated onto the aluminum substrate. The samples are made at a melt temperature of 302° ± 6° C and a line speed of 440 feet per minute.

The adhesion of Layer A to the aluminum substrate for each of the samples is determined using a 180 degree peel test based on ASTM standard F904 with a crosshead speed of 10 inches/minute. At least five samples of each Comparative/Inventive Example are measured, and the average values and standard deviations are calculated. The results are shown in Table 2:

Table 2

Property	C.Ex. A	C.Ex. B	C.Ex. C	I.Ex. 1	I.Ex. 2	I.Ex. 3	I.Ex. 4
Foil adhesion (N/in.)	--	2.30 ± 0.13	0.19 ± 0.05	2.24 ± 0.65	2.26 ± 0.29	n.d.	2.47 ± 0.35
RVR	N/A	N/A	1.33	0.308	0.042	0.167	0.167
Viscosity ratio	N/A	N/A	0.90	1.15	1.91	2.86	2.86

The RVR is determined from the melt indices (I_2) of the components of Layer A as described above. The viscosity ratio is the ratio of the viscosity at 190 °C and 1000 s^{-1} of the polyethylene component to the viscosity at 190 °C and 1000 s^{-1} of the ethylene/acrylate copolymer when measured as described above. For Comparative Example A, there is no measurable adhesion of Layer A to the aluminum substrate at processing conditions.

Inventive Examples 1 and 2 illustrate one advantage of some embodiments of the present invention--the ability to extrusion coat a metal substrate at temperatures lower than typically used for extrusion coating of LDPE only onto a metal substrate. Comparative Example A utilized LDPE only but did not have any measurable adhesion when extrusion coated at 302 °C, whereas Inventive Examples 1, 2, and 4 each exhibited desirable adhesion values when extrusion coated at that temperature. Inventive Examples 3 and 4 also demonstrate that LLDPE resins can be used in this invention to achieve similar adhesion results. However, Inventive Examples 3 did not perform well in extrusion coating. Thus, while Inventive Example 3 could be used to adhere to aluminum substrates when applied using other techniques, adjustments may be needed to make it suitable for extrusion. For example, as illustrated by Inventive Example 4, the ratio of components in Inventive Example 3 is adjusted (e.g., the amount of LLDPE is reduced) to make the formulation suitable for extrusion coating.

The neck-in and draw down speeds for these samples are also measured and the results are shown in Table 3 (in addition to the RVR and Viscosity ratios):

Table 3

Property	C.Ex. A	C.Ex. B	C.Ex. C	I.Ex. 1	I.Ex. 2	I.Ex. 3	I.Ex. 4
RVR	N/A	N/A	1.33	0.308	0.042	0.167	0.167
Viscosity ratio	N/A	N/A	0.90	1.15	1.91	2.86	2.86
Neck-in (in.)	1.875	4.5	4.625	5.5	3.5	n.d.	5.75
Draw down speed (fpm)	800	1500	1500	1150	800	400	1500
Reduced draw down speed (fpm)	N/A	1500	1025	N/A	N/A	N/A	1200

The neck-in (inches) is measured at a line speed of 440 feet per minute. The draw down speed (feet per minute) is the line speed when a web tear is observed while the screw within the extrusion coater is running at 90 rpm, which results in a flow rate of approximately 250 pounds/hour. The reduced draw down speed (feet per minute) is the line speed when a web tear is observed while the screw within the extrusion coater is running at 45 rpm. The

maximum value for draw down speed and reduced draw down speed is 1500 feet per minute, and the reduced draw down speed is only determined if the line speed reaches 1500 feet per minute when the extruder runs at 90 rpm. Table 3 illustrates that Inventive Examples 1, 2, and 4 exhibit performance properties that would be acceptable for extrusion coating applications, while Inventive Example 3 did not perform as well. As noted above, Inventive Example 4 demonstrates that adjustments can be made to the formulation of Inventive Example 3 (e.g., reducing the amount of LLDPE) to make the formulation suitable for extrusion coating.

Example 2

A variety of multilayer structures are prepared as shown in Table 4:

Table 4

	Layer A (percentages are weight %)	**Layer B (Substrate)**
Inventive Example 5	60% ELVALOY™ AC 1609 40% DOWLEX™ 2045	Aluminum substrate
Inventive Example 6	60% ELVALOY™ AC 1820 40% DOWLEX™ 2045	Aluminum substrate

Layer A is coated as a monolayer onto the aluminum substrate as described below.

All of these examples are prepared by extrusion coating the polymer layer (Layer A) onto the aluminum substrate (Layer B) utilizing a Black Clawson extrusion coater. Layer A in Inventive Examples 5 and 6 is prepared by tumble blending the prescribed amounts of the two components for approximately 30 minutes prior to feeding the blend to the extrusion coater. The aluminum substrate is dropped down onto the moving 50 pounds/ream Kraft paper just prior to the chill roll/rubber roll nip where the aluminum substrate is pulled into the nip thus applying Layer A onto the foil side of the aluminum substrate. The resulting flow rate from the die is ~10 pounds/hour of polymer per inch of die opening. A constant air gap of 6 inches is used in fabricating the sample. Each sample consists of a 1 mil thick monolayer of Layer A coated onto the aluminum substrate. The samples are made at a melt temperature of 313° ± 6° C and a line speed of 440 feet per minute.

The adhesion of Layer A to the aluminum substrate for each of the samples is determined using a 180 degree peel test based on ASTM standard F904 with a crosshead speed of 10 inches/minute. At least five samples of each Inventive Example are measured,

and the average values and standard deviations are calculated. The results are shown in Table 5:

Table 5

Property	I.Ex. 5	I.Ex. 6
Foil adhesion (N/in.)	4.17 ± 0.29	n.d.
RVR	0.167	0.125
Viscosity ratio	2.77	3.30

The RVR is determined from the melt indices (I_2) of the components of Layer A as described above. The viscosity ratio is the ratio of the viscosity at 190 °C and 1000 s^{-1} of the polyethylene component to the viscosity at 190 °C and 1000 s^{-1} of the ethylene/acrylate copolymer when measured as described above. Inventive Example 5 exhibited a desirable adhesion value when extrusion coated. In this particular case, adhesion values above 1.5 N/in are considered excellent; however, no further differentiation with other Inventive Examples can be made due to stretching of the peel arm. Inventive Example 6 did not perform well in extrusion coating, so it is difficult to compare its adhesion value. However, it is believed that Inventive Example 6 could be used to adhere to aluminum substrates when applied using other techniques, and that the ratio of components in Inventive Example 6 could be adjusted (e.g., reducing the amount of LLDPE) to make the formulation suitable for extrusion coating.

The neck-in and draw down speeds for these samples are also measured and the results are shown in Table 6 (in addition to the RVR and Viscosity ratios):

Table 6

Property	I.Ex. 5	I.Ex. 6
RVR	0.167	0.125
Viscosity ratio	2.77	3.30
Neck-in (in.)	2.00	n.d.
Draw down speed (fpm)	880	350
Reduced draw down speed (fpm)	N/A	N/A

The neck-in (inches) is measured at a line speed of 440 feet per minute. The draw down speed (feet per minute) is the line speed when a web tear is observed while the screw within the extrusion coater is running at 90 rpm, which results in a flow rate of approximately 250 pounds/hour. The reduced draw down speed (feet per minute) is the line speed when a web tear is observed while the screw within the extrusion coater is running at 45 rpm. The

maximum value for draw down speed and reduced draw down speed is 1500 feet per minute, and the reduced draw down speed is only determined if the line speed reaches 1500 feet per minute when the extruder runs at 90 rpm. Table 6 illustrates that Inventive Example 5 exhibits performance properties that would be acceptable for extrusion coating applications, while Inventive Example 6 did not perform as well. As noted above, the ratio of components in Inventive Example 6 may need to be adjusted (e.g., reducing the amount of LLDPE) to make the formulation suitable for extrusion coating.

Example 3

Other polymer blends according to some embodiments of the present invention can also be used to prepare multilayer structures. Examples of such blends, and corresponding multilayer structures, are shown in Table 7, with the RVR and viscosity ratios shown in Table 8. The polymer blends can be prepared as described above in connection with Inventive Examples 1-6.

Table 7

	Layer A (percentages are weight %)	**Layer B (Substrate)**
Inventive Example 7	60% ELVALOY™ AC 1609 40% AGILITY™ 1021	Aluminum substrate
Inventive Example 8	60% ELVALOY™ AC 1609 40% LDPE 132i	Aluminum substrate
Inventive Example 9	60% ELVALOY™ AC 1820 40% AGILITY™ 1021	Aluminum substrate
Inventive Example 10	60% ELVALOY™ AC 1820 40% LDPE 132i	Aluminum substrate
Inventive Example 11	80% ELVALOY™ AC 1609 20% AGILITY™ 1021	Aluminum substrate
Inventive Example 12	80% ELVALOY™ AC 1609 20% LDPE 132i	Aluminum substrate
Inventive Example 13	80% ELVALOY™ AC 1820 20% AGILITY™ 1021	Aluminum substrate
Inventive Example 14	80% ELVALOY™ AC 1820 20% LDPE 132i	Aluminum substrate

Table 8

Property	**I.Ex. 7/11**	**I.Ex. 8/12**	**I.Ex. 9/13**	**I.Ex. 10/14**
RVR	0.308	0.042	0.231	0.031
Viscosity ratio	1.12	1.85	1.33	2.20

We claim:

1. A polymer blend comprising:

a copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate having an acrylate content of 5 to 40 weight percent based on the weight of the copolymer and having a melt index (I_2) of 1 to 60 g/10 minutes, wherein the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises 45 to 99 weight percent of the blend based on the total weight of the blend; and

a polyolefin having a density of 0.870 g/cm^3 or more and having a melt index (I_2) of 20 g/10 minutes or less, wherein the polyolefin comprises 1 to 55 weight percent of the blend based on the total weight of the blend.

2. The polymer blend of claim 1, wherein the polyolefin comprises linear low density polyethylene, low density polyethylene, high density polyethylene, polypropylene, or a combination thereof.

3. The polymer blend of claim 1, wherein the polyolefin comprises low density polyethylene or linear low density polyethylene.

4. The polymer blend of any of claims 1-3, wherein the total amount of ethylene methyl acrylate copolymer and ethylene ethyl acrylate copolymer comprises greater than 50 weight percent of the blend, and wherein the polyolefin comprises less than 50 weight percent of the blend.

5. The polymer blend of any of claims 1-4, wherein the melt index (I_2) of the polyolefin is less than 10 g/10 minutes.

6. The polymer blend of any of claims 1-5, wherein the relative viscosity ratio of the polyolefin to the copolymer comprising ethylene and at least one of methyl acrylate and ethyl acrylate is <0.35.

7. A multilayer structure comprising at least two layers, each layer having opposing facial surfaces, wherein:

Layer A comprises the polymer blend of any of claims 1-6; and

Layer B comprises a substrate, wherein a top facial surface of Layer B is in adhering contact with a bottom facial surface of Layer A.

8. The multilayer structure of claim 6, wherein the substrate comprises a metal foil, a metallized film, a woven mat, a nonwoven mat, or a scrim.

9. The multilayer structure of claim 7 or claim 8, further comprising Layer C, wherein a top facial surface of Layer A is in adhering contact with a bottom facial surface of Layer C, wherein Layer C comprises a polyolefin.

10. The multilayer structure of any of claims 7-9, wherein the adhesion of Layer A to Layer B is at least 1.5 N/inch when measured using a 180 degree peel test based on ASTM F904 with a crosshead speed of 10 inches/minute.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/062282

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L23/04 B32B27/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08L B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/144703 A1 (BOREALIS AG [AT]; SCHININGER RENATE [AT]; KNIESEL CLAUDIA [AT]) 24 November 2011 (2011-11-24) table 1	1,2,4-6
X	US 8 772 410 B1 (CHOU RICHARD T [US]) 8 July 2014 (2014-07-08) example 4	1-6

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 February 2018	16/04/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rouault, Yannick

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/062282

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-6

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6

A composition as in claim 1

---

2. claims: 7-10

A multilayer as in claim 7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/062282

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011144703 A1	24-11-2011	BR 112012029566 A2	13-12-2016
		CN 102918099 A	06-02-2013
		EP 2571932 A1	27-03-2013
		US 2013203930 A1	08-08-2013
		WO 2011144703 A1	24-11-2011
US 8772410 B1	08-07-2014	NONE	